Asthma: The Regional Science Issues

Final Summary Report

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Preface

The U.S. Environmental Protection Agency's (EPA) Office of Research and Development (ORD) is currently pursuing new approaches for using science to address several topics of importance to the Agency. These topics represent new directions for EPA in that they transcend the traditional media- or pollutant-based boundaries and encompass a variety of disciplines and specialities. ORD wishes to link EPA staff interested in these topics with the appropriate science staff in ORD to identify areas for collaboration. To accomplish this goal, ORD's Office of Science Policy is hosting a series of New Directions workshops between March 1999 and Spring 2000. The workshops will provide a forum to present information and discuss current and future issues on new topics of interest. There are four topic series being presented under the auspices of New Directions: community assessment, reinvention, risk management, and regional science. Each topic series will consist of three or four workshops designed to bring interested staff together to develop a set of action items that will be completed over the course of the series.

The Regional Science workshops are intended to bring together scientists and others from EPA's Regional offices, ORD laboratories and centers, and interested program offices. Public and private stakeholders have assumed greater roles in both regulatory and non-regulatory aspects of environmental protection; EPA's Regions are in many cases best placed to interact with these stakeholders. In addition, the Regions are located where sector- and community-based environmental protection—two key components of EPA's new direction in environmental protection—is happening or can happen. Actions taken at the regional level have a major impact on EPA's national policy decisions in these areas. The Regions have identified asthma, transfer of science information, non-indigenous species, and Region 5's FIELDS system as the four areas that could most benefit from cross-regional/program collaboration.

The initial Regional Science workshop was held at the Doubletree Park Terrace Hotel in Washington, DC, on June 15-17, 1999. This workshop, entitled "Asthma: The Regional Science Issues," was designed to provide a forum for presentation and discussion between ORD and other EPA scientists regarding the science available to address asthma-related issues of interest to the Regions. It was intended to provide an opportunity to begin developing cross-Agency communications as part of ongoing and planned government-wide work to develop strategies for determining causes of asthma and reducing exposures to asthma triggers. Approximately 70 people registered for or presented at the workshop, representing EPA program offices, ORD, and several Regions; Appendix A provides a complete list of participants. David Klauder of ORD facilitated the workshop. The workshop was videotaped for distribution around the country. Appendix B provides a copy of the final workshop agenda.

Over the course of the two and a half day workshop, three specific objectives were addressed: (1) enhancing ORD's understanding of the nature of work ongoing in the EPA Regions to assess and mitigate community asthma clusters; (2) enabling the Regions and program offices to learn about research ongoing in ORD and across the Federal government which is addressing Regional asthma science issues; and (3) generating next steps for how the Regions can utilize the existing data and research products on asthma to further their efforts to address community asthma problems. To

accomplish these objectives, participants were asked to participate in discussions and provide input on the following questions:

- What was the most useful new knowledge you gained at the workshop?
- What are the most significant gaps in our knowledge important to assessing and mitigating asthma problems?
- With the knowledge from the workshop, what additional actions can the Regions take to enhance the effectiveness of their community asthma work?

Following presentations on effects and exposures, risk evaluation, risk management, and information issues, participants used these questions to shape their written comments and discussions. The comments, as well as flip charts generated during breakout sessions, were collected, typed into lists, and distributed to facilitate the discussions. During the final session of the workshop, ORD staff gathered to discuss ways in which they could assist the program offices and Regions, based on issues brought up during the workshop. Regional and program staff met to provide comments on the workshop and suggestions for the future. These lists are included as Appendix C.

This report summarizes the information that was presented and exchanged during the workshop. The organization of the report follows the agenda of the workshop. Key themes that emerged from the discussions are highlighted in Section 4 of the report. The report concludes with appendices containing a roster of attendees, the final workshop agenda, responses to the questions, and materials distributed to participants.

1. Introduction

1.1 New Directions Overview (Hugh McKinnon — ORD)

The New Directions initiative was introduced in a presentation by Hugh McKinnon, Deputy Assistant Administrator for Science within the U.S. Environmental Protection Agency's (EPA) Office of Research and Development (ORD). ORD's Office of Science Policy (OSP) is taking the lead in increasing scientific interaction within the Agency in several areas. Within the context of the workshops, OSP is creating an overall science inventory for the Agency. New Directions workshops are intended to bring EPA scientists, analysts, and managers together to discuss how new approaches to environmental protection are being addressed across the agency. Workshop sponsors believe that these discussions will produce cross-agency linkages that will strengthen science at EPA by fostering collaboration and coordination on scientific issues that cross traditional program and media boundaries.

Using input from ORD's national laboratories and research centers, as well as from program and Regional offices, OSP has identified community assessment, regional science, reinvention, and risk management as subject areas for the workshop series. While these four areas may not cover all the new scientific directions that EPA is taking, they encompass a wide range of cross-program and cross-media science issues. Each series will be comprised of three to four topic-specific workshops. Each workshop within a series will follow an agenda designed to focus on how analysts across the Agency approach the various topics, and how linkages can be formed among EPA program offices, Regions, laboratories, and research centers to collaborate and coordinate on issues relating to the topic area.

The Regional Science topic area will include workshops on asthma, transfer of science information, non-indigenous species, and Region 5's FIELDS system. The goals of all these workshops include: (1) focusing on new science issues; (2) promoting dialogue among ORD laboratories and research centers and EPA regional and program offices; and (3) producing cross-agency linkages. ORD field offices exist around the country and are available to work with Regional offices.

The objective of the asthma workshop is to improve ORD and Regional communication on asthma and its environmental causes, particularly for children. Outputs include this summary report, the video of the workshop, and a forthcoming asthma web site. EPA hopes that the final outcome of this effort will be stronger programs available to local communities.

1.2 The EPA Focus (Bob Axelrad — Office of Children's Health Protection/OA

Historically, EPA has not been a visible player in the asthma issue. However, the asthma problem has received new interest from the Administration. Much work is already being done within the Federal government regarding asthma; EPA must not duplicate efforts but should integrate its unique work with that undertaken by the Department of Health and Human Services (HHS).

The prevalence of asthma is increasing, especially for poor and minority populations. However, the reasons for this disproportionate impact are not known, although environmental exposures, access to health care, and other areas are being considered. In addition, the exact causes of asthma are not known, therefore, neither are the proper techniques for primary prevention. On the other hand, some aspects of the issue are known and have guidelines associated with them, such as asthma triggers and their management. However, this information is not being used actively on a public-health level. EPA's role in the interagency strategy involves increasing research efforts on issues such as the causes of asthma besides allergens, the reasons that certain groups of people (such as Hispanics) have higher levels of asthma, and the ways in which EPA can complement work already being done, particularly with regard to environmental causes.

At this stage, EPA is primarily involved in the interagency asthma effort through the Centers for Children's Research. Five of these Centers are concentrating on asthma. In addition, EPA's Indoor Environments Division (IED) is focused on schools and day care, promoting changes to their indoor environments through the dissemination of EPA's Tools for Schools guidance. The Division has also recently distributed Public Service Announcements (PSAs) on Environmental Tobacco Smoke (ETS) as an asthma trigger in the home.

It cannot be overemphasized that EPA must incorporate its work into that of the other agencies, so as not to overlap or recreate work already done. Each agency is devoting resources to aspects of asthma research that correspond to their own missions. EPA's focus should be on the environmental causes and triggers of asthma, as well as environmental justice issues. In addition, there must be a balance between research and applying what is already known in practical interventions.

Workshop participants were particularly interested in involving the Department of Education in the issue. IED has worked with the Department on the Tools for Schools guidance, but the focus of the Department is more on education and strict safety issues such as guns and drugs. IED has found more success in working directly with the school districts on the issue.

Funds are being earmarked within EPA for asthma programs. IED has an asthma workgroup, which promotes internal planning and works with cooperative partners to provide money to communities in the form of discretionary funds and competitive grants. However, in order to focus funds on implementation, enough must be known about the issue to make the interventions credible.

2. Summary of Presentations

A series of presentations were given that covered all areas of the asthma issue. The presentations were divided into four sessions—effects and exposure issues, risk evaluation issues, risk management issues, and information issues. Over the course of each day, workshop participants were asked to consider the presentations they heard and note their answers to two questions: (1) What was the most useful new knowledge you gained during these presentations?; and (2) What are the most significant gaps that still remain in relation to the topics just presented? The essence of the discussions are described in Section 3. Brief summaries of the presentations are given below.

2.1 Effects and Exposure Issues

2.1.1 What are the Basic Aspects of Asthma? (Hillel Koren - ORD)

There are almost 15 million asthmatics in the United States, resulting in 15.5 million outpatient visits and 415,000 hospitalizations per year. Approximately 5,000 people in the United States die each year from an asthma attack. Asthma also causes a significant economic impact, not only from the direct health care costs associated with treatment but also substantial indirect costs, such as absenteeism from work and lost productivity. The incidence and severity of asthma is increasing worldwide, despite the fact that ambient air pollution levels have dropped over the past ten years. This increase has occurred disproportionately among African Americans and other minorities in the United States. Poverty has been suggested as the reason for this; however, asthma is relatively lower in Africa, where poverty is quite high. It has also been considered that the answer lies in lifestyle changes, where changing to a less "traditional," more Western lifestyle marks an increase in asthma incidence. In Australia, however, higher rates of asthma are found in the rural, rather than the urban, parts of the country. These examples illustrate the complexity of the asthma issue.

Asthma is a complex, multi-factorial disease characterized by reversible airway obstruction, non-specific airway hyperresponsiveness, and mucus hypersecretion; it is a chronic airway inflammatory disease with episodes of acute exacerbation. A complex network of immune cells, effector cells, cytokines, and other mediators interact to produce the asthmatic response. Asthma can vary widely in severity, both between and within individuals, but common symptoms include wheezing, shortness of breath, cough, chest tightness, and mucus production. Typical features of asthma include an increased level of immunoglobulin E, a positive reaction to inhaled allergens, and exaggerated bronchoconstriction in response to airway cooling or drying, exercise, and chemical or pharmacologic bronchoconstrictors (e.g., histamine or methacholine). The disease can be divided into two general categories, e.g., extrinsic and intrinsic. Extrinsic allergic asthma involves hereditary factors and allergens and is detected by the presence of serum IgE. Most childhood asthma falls into this category. Intrinsic asthma, which is more common in adults, does not involve these factors but results in similar pathobiology and treatment as extrinsic asthma.

Asthma is triggered by many factors in the environment, including house dust, pet dander, fungi, and cold air. Food allergens and stress can also trigger the condition. Genetic risk factors play a significant

role in determining which people show signs of asthma, given similar exposure scenarios. The presence of atopy is a risk factor for developing overt asthma. If one parent is atopic, half of the children will have atopy. If both parents are atopic, 75 percent of the children will have atopy. If neither parent is atopic, there is a 15 percent chance of having an atopic child, which means that the potential for asthma exists. While there is certainly genetic control of asthma, there is no single gene responsible for its expression. The interaction between the environmental and genetic risk factors results in clinical asthma and the pathologic abnormalities of asthma, including bronchospasms, mucosal edema, airway inflammation, increased mucosal secretion, and a thickening of the basement membrane. While a normal airway has a well-organized epithelium, an asthmatic airway has a disrupted epithelium, is constricted, has a mucus hypersecretion plug, enlarged smooth muscle cells, and an inflamed basement membrane.

During the first hour after asthma attack, there is an initial drop in lung function and then an oscillation in function which decreases in a few days. Repeated episodes of airway inflammation can cause long-term structural damage and weakness, making the airways more prone to damage during the next attack. For this reason, it is important to control asthma so that the condition does not worsen.

Airways hyperresponsiveness alone is not necessarily diagnostic of asthma. Airway inflammatory cells in asthmatics characteristically include eosinophils, other polymorphonuclear granulocytes, and lymphocytes. Injury of the airway epithelium is present to varying extents, even in individuals with mild asthma. Evaluation of a patient with suspected asthma includes family, exposure, and social history. Tests for IgE antibody, pulmonary function, and allergy skin tests are conducted. The severity of asthma is different for any asthmatic and can range from mild, moderate, to severe persistent asthma, depending on the degree of exacerbation, activity levels, and compromise of pulmonary function (peak air flow).

The management and treatment of asthma involves working with the patient to develop treatment goals and an action strategy. Goals might be to prevent chronic and troublesome symptoms, prevent acute attacks, and continue all activities. The patient is provided with written, individualized instructions, a daily plan for management, and the long-term benefits of following the plan are discussed. The patient is taught how and when to use the peak lung flow meter, which can predict some asthma attacks. Medications are also helpful for control and include a regime of beta-agonist inhalers and steroids.

Poor disease management, lack of accessibility to medical services, inadequate advanced planning, and lack of outdoor exercise may contribute to the increased incidence and severity of asthma. In addition, it is possible that the decreased prevalence of infectious diseases has had an affect on the immune system, enhancing the response to allergens. ETS and other indoor air quality issues may also play a role. In summary, asthma appears to be a disease of modern, industrialized, affluent societies.

2.1.2 How are Environmental Factors Linked to Asthma? (Lucas Neas - ORD)

Genetic factors, viral and parasitic infections, diet, lifestyle, air pollution, and allergen sensitization are all linked in some way to asthma. However, none of them alone can be considered the source of the recent upward trend in asthma cases. While genetics are certainly a factor, they do not change quickly enough for a genetic shift to be the cause of the trend. However, genetic factors predispose people to

asthma, who are then forced over to active asthma by an increasingly "adverse" environment. The decrease in infections, due to vaccination and smaller families, means that there has been an overall decrease in the necessity for an immune response to certain diseases. This may sensitize the body to asthma-related allergens. However, this decrease has occurred since the 1960s while the asthma trend is more recent. With regard to diet, it has been found that antioxidants are more protective and an increase in trans-fatty acids, salt, and sugar in the diet due to junk food may be a risk factor. There has certainly been an increase in the consumption of junk food in the United States since the 1960s, but there is a question as to whether this would explain the worldwide trends. The levels of exposures due to indoor and outdoor antigens may have increased, including on an occupational and even community-wide level. Early childhood exposures to dust mites, humidified homes, cockroaches, cat dander, mold spores, and pollen may have increased. However, this does not explain why asthma incidence seems to increase after moving from an urban poor environment to a rich environment. This phenomenon has been seen in Ghana. Other research has looked at lifestyle causes, such as the lack of general time outdoors, particularly spent engaging in vigorous activity. Data have shown that living on a farm provides protection from asthma; this may mean that today's children spend too much time on indoor activities which increases their exposure to indoor pollutants over time. In addition, pulmonary "exercise" results from general time outdoors. However, if outdoor activity is promoted, it is necessary to ensure that the ambient environment is not polluted.

Air pollutants have been considered as asthma triggers. However, air pollution has decreased over the past decade while asthma cases and severity have increased. For example, the dramatically cleaner air that resulted from the shutdown of many plants in the former East Germany did not result in changes of asthma rates. In fact, while eastern Germany has more bronchitis and wheeze associated with airborne irritants, they also experience lower rates of asthma and hay fever than in western Germany. In addition, New South Wales, Australia has high rates of asthma but a clean environment.

The Harvard Six-Cities Study and 24-City Study in the United States and Canada looked at the prevalence of respiratory illness in children vs. air pollution. Bronchitis was associated with air pollutants but asthma was not. A study performed in Kanawha County, West Virginia showed an association between volatile organic compounds (VOCs) and other traffic-related pollution and asthma on a city-wide scale.

Based on these studies, it appears that air pollutants may play a greater role as a trigger or exacerbation of asthma but not as a cause, although they may increase the possibility of sensitization to antigens and bioaerosols. Air toxics, such as those associated with traffic, present an area needing further study.

2.1.3 What is ORD's Role in the Larger Federal Context? (Hillel Koren - ORD, Marshall Plaut - NIH, David Mannino - CDC, Mike Hodgson - NIOSH)

ORD's role in the asthma issue is primarily to articulate important environmental research questions related to asthma, particularly the interactions between asthma and the environment. In particular, it is important to determine the role of pollution in exacerbating asthma, since EPA regulates many pollutants and works with environmental justice issues. The study of asthma biomarkers, epidemiology, controlled

human exposures, human and animal dosimetry, animal models of asthma, animal toxicology, and in vitro toxicology are all important. Priority research areas have been identified in *Asthma and the Environment: A Research Strategy for the National Health and Environmental Effects Research Laboratory (NHEERL)* and include: (1) the induction of asthma; (2) the exacerbation of existing asthma; (3) the causes of amplified responses or enhancement of existing asthma; and (4) the identification of susceptibility factors. Areas specific to asthma induction include (1) the role of pollutant exposures; (2) interactions between pollutants and viruses, ETS, and allergens; and (3) pathogenic mechanisms of irritants. Areas to study regarding asthma exacerbation include: (1) short-term exposure to indoor and outdoor pollution; (2) outcomes of acute exposures; and (3) occupational exposures. In addition, ORD has an important role in conducting research to develop effective technologies, methods, and procedures to prevent and mitigate exposures to environmental allergens.

The National Institutes of Health (NIH) conducted two Inner City Asthma Studies between 1991 and 1996 and 1996 to the present. The studies primarily looked at African American and Hispanic children in urban areas and evaluated strategies to improve their asthma. The first study looked at risk factors and evaluated one intervention program for a group of 1,500 children ages 4-9, living in the Midwest and Northeast. Risk factors included poverty, poor access to health care, discontinuity of care, poor self-management skills of the children's caretakers, ETS, and cockroach allergen (both for children who were allergic and those who were receiving heavy exposure). The intervention program involved 1,033 children ages 5-11. Asthma counselors were provided for groups and individuals who taught self-management skills for asthma. Cockroach reduction was also conducted. This resulted in some symptom reduction. The second study examined additional interventions for children, ages 5-12, with more severe asthma at seven sites in the Northeast, Midwest, and Pacific Northwest. One intervention involved the mitigation of indoor allergens and caretaker education regarding mitigation techniques. The second involved a computer program that provided feedback to physicians to improve the quality of care.

The Centers for Disease Control (CDC) does not have a large budget for asthma issues. However, it does track national trends of morbidity and mortality through surveillance and conducts some prevention-oriented research. CDC has found that there is a disparity in asthma among different parts of the country. For example, the Northeast experiences more hospitalizations than other parts of the country. Puerto Ricans have been found to have a greater prevalence of asthma than other Hispanic groups, perhaps because they tend to live in the Northeast. Prevention-oriented research includes attempts at preventing morbidity and mortality, and covers topics such as ETS, outdoor air quality, and patient management to decrease asthma-related emergency room visits and hospitalizations. Asthma is a public-health problem and as such, CDC is attempting to involve State and local health departments to a greater degree in asthma control and prevention.

The National Institute for Occupational Safety and Health (NIOSH) conducts basic and applied research, provides technical assistance and health hazard evaluations, and offers training and recommendations. However, NIOSH does not have regulatory authority. At this time, NIOSH is involved in the asthma issue in schools, with regard to the health effects of poor indoor air quality on teachers, and receives many requests for health-hazard evaluations in schools and other buildings. One area for interaction between NIOSH and EPA is in the schools, since the focus of NIOSH is on the

workers in the school, not the children. NIOSH assesses exposures based on the physical conditions of the building envelope, including bioaerosols and endotoxins. In conjunction with EPA's IED, NIOSH is also providing recommendations to schools on health problems.

2.1.4 How Do We Study Asthma and Environmental Factors? (Lucas Neas - ORD, Haluk Ozkaynak - ORD)

Instrumentation to sample air for particles and gases was presented. These included instruments to measure particles less than 2.5 microns (or m) and a Burkhard sampler, which collects particles greater than 2.5 . Dust sampling can be done by measuring concentrations of particles in the atmosphere with a light scattering device. These instruments make very detailed characterizations of particles possible for both characterization and origin. The cost of these instruments ranges from $1,000 to $3,000, plus peripheral components such as pumps and technician time. Analysis of the samples range in cost; filter weighing is the least expensive at about $50 per sample, while chemical speciation, scanning electron microscopy, and organic compound analyses are more expensive. The information can be used to study the association between pollutants and acute asthma attacks. Passive samplers for personal use, in the form of badges, are cheaper but less reliable. They can be useful for epidemiologic studies of exposures from multiple locations, and the cost of analysis ranges from $30 to $60.

Techniques for checking respiratory status were also demonstrated. These methods can be used to test children in schools and they range in invasiveness. The least invasive technique involves the use of a respiratory symptom questionnaire that asks questions about morning cough, doctor's diagnosis of asthma, chest symptoms apart from a cold, wheezy chest, bronchitis, and earaches. This information can be very useful but depends on the ability of the subject or parent to recall and report the information accurately. A $20, plastic peak flow meter was demonstrated, which can be used to tell when a child having an attack should be taken to the hospital. This instrument does not have a lot of predictive value because as children grow, their peak flow naturally increases. Peak flow also depends on the level of effort used in blowing, the time of day, and how often the test has been repeated. Peak flow in children has been shown to be lower on days that are associated with a peak of molds, mildews, and particle acidity. One device measures pressure differential. When the subject blows across the mouthpiece, data are displayed on a computer screen. This is used in epidemiologic studies to find a change in forced vital capacity between different test sites. Children who are below 85 percent of their expected lung capacity are of concern. Finally, nasal lavage is the most invasive of the techniques described here, but compared to other procedures, it is still relatively non-invasive, low risk, and can be applied safely to children. This technique allows cells from the upper respiratory track to be sampled, giving clues as to the condition of the lower respiratory tract. Lavage can also be done by inducing sputum or directly sampling the lower respiratory tract.

2.1.5 What is the Role of Molds in Asthma Severity and Incidence? (Mike Hodgson - NIOSH, Barbara Spark - Region 9)

Moisture in the home has been associated with chest symptoms such as wheezing and coughing, as well as indicators such as absence from school. Moisture can be present in the basement, through roof

leaks, and window and wall condensation. Moisture flow is the best predictor of the total bioaerosol burden and results from the use of substandard housing stock and inadequate insulation.

It is estimated that 15-20 percent of adult asthma is work-related. Diagnosis of asthma often occurs after one year of working in an implicated office building, where water damage or moisture in the heating, ventilation, and air conditioning (HVAC) system may be visible and the presence of molds is detected. Peak flows may appear lower during working hours only. Existing cases of asthma may be exacerbated by working in such a building. Often, asthma cases are sentinels for moisture-related problems endemic to the building. The SENSOR program attempts to identify sentinel asthma cases and initiate intervention activities.

It is estimated that 25-35 percent of the population in the United States is atopic, or genetically predisposed to develop allergies or asthma. Exposure assessments are complex because they should, and often do not, take into account factors such as sampling of the personal cloud and areas of pollutant reservoirs, e.g., carpet. In addition, when considering exposure to "fungi," it must be determined whether this refers to fungi, bacteria or slime molds. At this point, the data do not exist to determine the exact relationship between fungi and asthma. For example, are the effects of fungi due to allergic reactions or toxins in the fungi? In practice, fungi is mitigated when it is seen, but the data are not available at this time to evaluate the exact effectiveness of this mitigation on health.

Members of the public are concerned about moisture-related molds based on their association with undiagnosable disease. From the perspective of the public, these two conditions appear related. However, "mold" is not simply one substance but is made up of many different types of organisms. This makes epidemiologic studies difficult to conduct. Research questions, therefore, include determining how much of what type of mold exposure is too much. At this time, the American Conference of Governmental Industrial Hygienists (ACGIH)'s guidance for controlling asthma has deleted a recommendation to prevent and remediate mold growth because a link with asthma has not been conclusively shown. However, many members of the public are already associating the presence of molds with asthma attacks. They often bring these concerns to the EPA Regions.

2.1.6 What are the Interactions Between Air Pollutants and Allergens? (Howard Kehrl - ORD)

There is a potential interaction between exposure to allergens and exposure to air pollutants and asthma. For example, it has been found that the presence of diesel exhaust and an allergen results in higher levels of IgE than with the allergen alone. The same effect occurs with other air pollutants, i.e., there is an increased response to an allergen because of the presence of an air pollutant.

Ozone exposure has been shown to enhance eosinophilic inflammation of airways in asthmatics and augments the response to allergens. This means that asthmatics exposed to ozone are more likely to have an increased response to another asthma trigger. Not only does ozone exacerbate existing asthma, causing the body to require less of an existing allergen to induce symptoms and a cellular response, but it also has direct effects. Exposure to ozone directly causes symptoms of cough and shortness of breath and decrements in lung function.

Similar effects are seen with particulate exposure. Diesel Exhaust Particle (DEP) has been found to increase the effects of ragweed on an asthmatic. DEP increases IgE production and allergic inflammation in asthmatics.

After exposure to certain air pollutants, less of a particular allergen is necessary to cause the same reaction as when air pollution is not a factor.

2.1.7 How Are Exposures to Environmental Contaminants Related to Asthma? (Steve Vesper - ORD, Lance Wallace - ORD)

Overall, the fungus-associated allergies have been the least studied. Little data are available on the distribution of airborne fungal products, dynamics of human exposure, nature of the allergens, factors influencing the quality of skin test and immunotherapy materials, and the nature of fungus-related allergic disease. Therefore, focus for research should be on initiating and conducting studies to determine the relative etiologic importance, geographic distribution, and concentrations of airborne fungus material associated with indoor allergy.

Some contaminants have been associated with asthma and other respiratory conditions. For example, *Stachybotrys* has been associated with infant deaths and other conditions; *Penicillium chysogenum* is associated with asthma; *Aspergillus sydowii* was identified as the cause of "sea-fan" deaths in the Caribbean; and *Aspergillus versicolor* is associated with IAQ problems, possibly asthma. Fungal spores can be identified by examining dust under a microscope; however, there are also many particles that cannot. Novel DNA techniques can be performed on a single spore to determine the origin of the particle.

Chemicals are also a source of environmental exposure that may be linked with asthma. EPA's TEAM study investigated pesticides and found that the chemicals can build up in house dust, which toddlers ingest and which is also tracked around on shoes. Other major sources of chemical exposure include personal activities, building materials, and consumer products. Certain substances can be more directly linked to sources. For example, 90 percent of benzene intake comes from ETS and smoking while three percent comes from industry. Chloroform is associated with dairy products and washing clothes. Perchlorethelyne comes from dry cleaning. Exposures are greater indoors than outdoors for 35 of 36 hazardous chemicals. However, one particular area of interest is on the level of exposure to a mix of toxics associated with driving in traffic.

Research has been conducted on the mitigation of dust buildup. Methods include using a stronger type of vacuum with a sensor that tells the user when dust levels are at a certain point. However, the time needed to reach this point is too long to be practical. Air cleaners have also been investigated. Different types of air cleaners are effective on different types of contaminants but it is uncertain whether their use actually helps with asthma.

2.2 Risk Evaluation Issues

2.2.1 What Risk Questions are Communities Asking? (Mary Beth Smuts - Region 1)

Mary Beth Smuts, Regional Air Toxicologist for Region 1, presented a case in Lawrence, Massachusetts as an example of a community asthma problem. Lawrence is the 23rd poorest city in the United States and has a high proportion of Hispanics. The city also has a high rate of asthma; in one particular area, asthma prevalence was six times the State rate. Lawrence is a mill town, where both textile factories and workers' homes are located. Dust from the mills, as well as several incinerators, facilities included in EPA's Toxic Release Inventory, and a major highway, have been associated by community residents with asthma and other respiratory and pulmonary conditions.

Four towns in the area joined together and worked with EPA to resolve these issues. When asked about their greatest concerns, they identified the shutdown of the incinerators as their ultimate goal. The group specified that they did not want a traditional risk assessment based on cancer but rather one based on asthma endpoints. They wanted a comprehensive inventory of local pollutants based on an occupational list of chemical agents for asthma, which would provide information on cumulative exposure. In a traditional risk screening approach, items would be dropped from consideration if they were below a hazard index level. However, this is not necessarily appropriate when looking at asthma.

A second case in the affluent community of Farmington, Connecticut illustrates the problem using traditional risk assessment for asthma issues. Since 1989, this community contains a small industrial facility that works with polymers and small plastic emissions. Homes surrounding the facility were on a level with the smokestack from the facility. A series of time-dependent asthma cases and related problems caused the State health department to issue a cease and desist order for factory operations. The case was taken to court, where the court concluded that, based on a traditional risk assessment, there was no threat to public health. However, some chemicals emitted by the factory were not on the standard list of air hazards. There were other uncertainty factors as well. This case raises an important question: are risk assessments that look at a standard population sufficiently protective of sensitive subpopulations, such as those susceptible to asthma?

Even where scientific data do not exist to definitively draw links between certain factors and asthma, anecdotal and epidemiologic evidence on the community level may provide clues that should not be ignored for lack of data. For example, in a housing project in Boston, Massachusetts, it was found that lead poisoning and asthma rates were high in the same neighborhoods. In fact, houses with children who had experienced lead poisoning were three times more likely to have children admitted to the emergency room for asthma attacks. In another case in Kansas City, although EPA did not believe that a cluster of asthma cases were related to *Stachybotrys* exposure, that contaminant was found in 11 of 15 homes of asthma patients studied. EPA learned from this experience to listen to the concerns of the community even when the complaints at first may not fit expectations based on data.

However, research must also avoid being subjective. In some cases, a community believes that it has an asthma problem and demands that EPA look to the nearest factory as a culprit. It is also easy to diagnose illness or sources according to the current media stories. For example, the current media

attention given to molds has created a huge amount of public concern. In these cases, it is very difficult to convince the community to consider other possible sources of asthma, including those that EPA cannot regulate, such as indoor air quality. Although the perceptions of a community may initiate the focus of Regional EPA investigations, agreement must be reached with all stakeholders, including the State and local governments, affected industries, and citizens groups. This must be done while at the same time maintaining the integrity of EPA's scientific work.

2.2.2 What Test Methods and Guidelines Exist to Evaluate the Risks from Exposures to Asthmagens? (Mary Jane Selgrade - ORD; Mark Greenbert - ORD; David Mannino - CDC; Lucas Neas - ORD; Larry Folinsbee - ORD)

Chemicals or other environmental agents could potentially affect allergic asthma in one of two ways. They themselves might act as allergens or they might enhance sensitization or the subsequent responses to common allergens such as dust mite. At this time there is no official test guideline that can be used to determine whether chemicals induce or aggravate allergic asthma. Research is underway to develop such test methods using animals. Animal data generated by the application of test guidelines would be useful to establish a cause and effect relationship between exposure and asthma for chemicals implicated by epidemiology, to identify potential hazards that might be associated with exposure to new chemicals before large numbers of humans are exposed, and to establish dose-response relationships.

When evaluating risks associated with allergens, there are two doses response of concern. The dose required to initially sensitize an individual (induction phase) is usually higher than the dose to trigger symptons in a previously sensitized (the challenge phase).

There are two types of allergens: proteins are able to elicit immune responses on their own; haptens (low molecular weight compounds) are too small to elicit an immune response on their own and must first react with a host cell protein before they can elicit an immune response. Protein allergens include mold, dust mites, cockroaches, animal dander, microbial pesticides, and detergent enzymes. Proteins are not equally allergenic; some proteins are more prone to be allergens than others. Methods are currently being developed to rank the relative potency (as allergens) of proteins based on the IgE antibody response following sensitization of laboratory animals. There are approximately 40 low molecular weight compounds that have been associated with allergic asthma. These include some chemicals that are listed on the urban air toxics list. However, unlike the protein allegens, it is not clear that IgE is the appropriate endpoint to use in assessing the potential allergenicity of low molecular weight compounds. Research to identify the appropriate biomarker is currently underway.

For some allergens there is enough human data to establish safe exposure levels. Inclusion of these allergens in a relative potency ranking based on animal testing provides means to extrapolate from animal test data to human health effects. Research is also underway to develop animal models of allergic disease that can be used to determine whether environmental chemicals exacerbate the induction of expression of allergic responses to allergens such as dust mite.

Few reference concentrations have considered the hazards of pollutants with regard to asthma. In part, this is because of a lack of data and limitations on studies, including previous exposures,

incorporation of genetic predisposition, and a lack of specific biomarkers. In considering pollutant hazards, it is important to look at the effects of both elevated levels and chronic exposure to lower levels, both of which may affect asthma.

Linking environmental triggers to asthma can be easier, because the triggers may be associated with a particular activity at a particular point in time, such as dust from soy bean unloading, volcanic eruptions, forest fires, or ozone. On the other hand, investigating the increase in the prevalence of asthma requires examining less-obvious sources, such as genetic factors, prenatal exposures, early childhood infections, occupational exposures, and others.

Because asthma is a multi-dimensional disease, it is important to define it consistently and ensure that physician diagnosis is not increasing the prevalence. Current data come primarily from cross-sectional studies; it is important to also conduct case-control studies and compare risk factors between the cases and controls.

SO_2 is one of the primary air pollutants of concern for asthma. Sources of SO_2 are mainly stationary and include pulp and paper mills, smelters, and fossil fuel combustion. Other possible sources of SO_2 exposure that should be studied include indoor exposure from combustion appliances and exposures inside cars. Asthmatics are most affected by SO_2 when exercising, when they experience wheezing, chest discomfort, increased airway resistance, and decreased lung function. This response is modified depending on the concentration of SO_2, exercise or ventilation levels, breathing through the nose as opposed to the mouth (the nose scrubs out some SO_2), changes in temperature and humidity, and medications. The duration of exposure also plays a role. Response is maximized during the first 5-10 minutes for up to thirty minutes after exposure. For 5-6 hours after exposure, the body is less sensitive to SO_2.

In a controlled exposure study, researchers determined that the amount of SO_2 which causes a doubling in bronchoconstriction, or the provocative concentration, is 0.75 parts per million (ppm). A resting asthmatic will experience a response at one ppm, although it may resolve rapidly without medication. This work provides the basis for setting a short-term standard for SO_2. Asthmatics have been found to be ten times as sensitive to SO_2 as non-asthmatics. In addition, brief periods where concentrations exceed 0.50 ppm do occur. While inhalers can help block the SO_2 response, they must be used just before exposure, which is not always known. Asthmatics exercising outdoors have the highest risks. It is estimated that about 500,000 asthmatics live close to a source of concern, and one to three percent of these people will have an exposure one to two times per year. Possibly 70,000-165,000 incidents could be averted each year by a short term standard.

2.3 Risk Management Issues

2.3.1 How Do We Determine Appropriate Mitigation Approaches? (Bruce Henschel - ORD)

Inhalation is generally assumed to be the primary exposure route of concern for asthma, including both persistently airborne and re-suspended contaminants. Classes of control options to be considered include ventilation, air cleaning, and source management. The most formal mitigation guidelines have

been published by the National Asthma Education and Prevention Program (NAEPP) at NIH. These guidelines for allergen control were created through consensus by leading American scientists. Some control options were omitted, probably because of a lack of consensus regarding performance, cost, or practicality. These include removal and replacement of bio-contaminated materials that are porous, air cleaning, using acaricides and denaturants against mites, carpet cleaning, duct cleaning, and frequent washing of pets. In addition to the NAEPP guidelines, less formal guidelines appear in, e.g., the peer-reviewed literature and in brochures prepared by various entities for the general public.

ORD has several ongoing and proposed mitigation projects within the Inner City Asthma Study (National Exposure Research Laboratory (NERL)/NHEERL) and within five of the eight Children's Health Research Centers (National Center for Environmental Research and Quality Assurance (NCERQA)). EPA's National Risk Management Research Laboratory (NRMRL) is developing and testing mold-resistant building materials**,** working to determine which control measures in fact reduce exposures and health effects, and demonstrating methods for reducing indoor concentrations of airborne asthma enhancing agents. A report on the efficiency of mitigation strategies, among other things, is expected at the end of September 1999 from EPA's Office of Radiation and Indoor Air (ORIA). At least half of the Regional Offices are involved in an inner-city intervention project.

2.3.2 What are Some Practical Approaches for Managing Cockroach and Pet Allergens? (Rachel Chaput - Region 2)

Allergen mitigation strategies are affected by the size distribution of the allergen. Cockroach allergens, or *Bla g* 1 and 2, are relatively large and heavy (in general over 10 microns) and are not in general found in the air except briefly following disturbance. Dog and cat allergens (*Can f* 1 and *Fel d* 1), on the other hand, are predominantly smaller than 10 microns, and tend to remain airborne longer, some particles almost indefinitely.

Cockroach populations in the home may be controlled through the application of integrated pest management (IPM) techniques, which include a combination of sanitation, placing barriers to pest access, removal of food and water sources, and extermination with the lowest-risk methods possible. A popular and relatively low-toxicity cockroach pesticide is boric acid powder, as it is long lasting and effective. However, a number of studies, including the National Cooperative Inner City Asthma Study, have shown that it is easier to control cockroach populations than it is to remove their allergens. Reasons for this are uncertain but probably primarily involve recurring roach populations and reservoirs of their allergens in the home, as well as the transport in of both roaches and allergen from outside the home. An IPM demonstration project has been conducted in EPA Region 2 and we believe that a very thorough sealing of all entryways into the home, combined with thorough cleaning and sanitation, can be an effective and sustainable method of not only eliminating cockroach populations but of reducing exposure to their allergens. To date, studies that have been conducted have for the most part ignored the critical element of sealing cracks and holes in the home, a time-intensive method which not only greatly reduces pest access to the home, but also reduces the amount of allergen-laden dust (which is often extensive) that can filter in from the building infrastructure.

In a study by Wood in 1998, HEPA air cleaning was found to reduce airborne *Fel d* 1 after pets were removed; however, no symptom change was noted. Pet allergen can be controlled to a varying extent by a combination of techniques. Removal of the pet, while often the least desirable option to the patient, is often the only way to significantly reduce exposure to pet allergens, and even this method must be supplemented with extensive cleaning to achieve these reductions. Other commonly recommended methods include restricting the pet's movement, the use of HEPA air filters, removal of allergen reservoirs such as carpets or upholstered furniture, and ventilation. Use of allergen-impermeable mattress and pillow covers is recommended, with the effective pore size of the covers being 6 microns or less. Vacuuming should be performed either with HEPA vacuums or with a standard vacuum using double thickness bags to avoid redistributing of the allergen. Wet vacuums tend to aerosolize the contents of their water tanks, and therefore are not desirable. Pet washing is often recommended, but appears to be of questionable value. Washing pets (especially by immersion) removes a good deal of allergen and reduces the allergen load entering the home, however relative to airborne levels its effect is transient, in fact significantly less than one week.

2.3.3 What Works/Doesn't Work in Reducing Exposures to Dust Mite Allergens? (Bruce Henschel - ORD)

Dust mites were one of the first allergens identified in relation to asthma. Approximately 50-75 percent of asthmatics are sensitive to dust mites, and it is physically impossible to completely eradicate dust mites in the home. The NAEPP recommendations are to encase both the mattress and the pillows in either natural or synthetic material that are impermeable to both the mites and their allergen, and to wash the bedding weekly at above 130°F. Secondary recommendations include reducing relative humidity to below 50 percent (which is difficult to implement), avoiding upholstered furniture, removing carpets, and removing or washing stuffed toys. Vacuuming twice weekly with a high efficiency machine is recommended for long term reduction of dust mites, as long as dust exposure is avoided while vacuuming through the use of a HEPA filter or double layer bag. NAEPP does not include carpet cleaning or use of acaricides and/or denaturants, because the dust mites are located too deep in the carpet. It also does not include air cleaning, improved ventilation, duct cleaning, and use of synthetic bedding in its recommendations. The effectiveness of these measures has not been proven.

However, following these guidelines may not result in clinical improvement, although some of them are effective in reducing mite allergen concentrations, e.g., in the bedding. This is likely because there are other sources of mite allergen exposure, or because the patient is also sensitized to other allergens. Some methods that are not recommended require more study, such as duct cleaning. There are minimal data gaps remaining for major risk management options. Instead, remaining issues are associated with exposure assessment and how these methods must be implemented to achieve clinical benefits. Another issue to be addressed is methods for improving the patient's implementation of these avoidance measures. Other issues possibly warranting consideration include development of standardized industry protocols for verifying the performance of avoidance devices on the market (e.g., "anti-allergenic" vacuum cleaners), and assessing the durability of bedding encasements.

Care must also be taken when recommending washing at 130°F; not only is this difficult for low-income people who wash in a Laundromat, but washing at this temperature is dangerous for burns and

is specifically not recommended around children. More practical alternatives, such as lowering the water temperature but including acaricides in the wash water, drying clothes in sunlight or for an hour in a hot dryer, should be investigated.

2.3.4 What is the Role of Particle Air Cleaners for Asthma Risk Management? (Bruce Henschel - ORD)

Air cleaners are not explicitly recommended in the NAEPP guidelines but can be useful. The choice of an air cleaner depends on the type of contaminants that require removal. For particulate removal, flow-through media air filters, electrostatic precipitators, and combined media/electrostatic filters can be considered, either free-standing or duct-mounted; ionizers for particle removal are also on the market.

Only high-efficiency flow-through particle air cleaners are likely to be helpful for asthma risk management. High-efficiency media air filters are probably a better choice than an electrostatic precipitator; media filters can give better initial removals, and precipitator performance can degrade significantly without proper maintenance. Media filters include HEPA filters; while HEPA units may not always be necessary when the mean particle size is sufficiently large, they are generally always advisable to handle the finer size fraction that will often be present. Ionizers are not expected to be helpful.

Inhalation exposures to particles can occur from persistently airborne particles (typically on the order of 1 m), and from re-suspended particles (which conceptually form a dust cloud around a person after disturbance, but then re-settle, sometimes rapidly). Properly selected flow-through air cleaners can nominally remove up to 99% even of sub-micron particles; so the issue is not so much the ability of the air cleaner to remove the particles that pass through it, but rather, the ability to circulate the particle-containing air through the air cleaner fast enough. Theory and experience indicate that, because of this circulation issue, air cleaners will generally not provide sufficient reduction in total or peak exposure to relatively large (>10 m), rapidly settling re-suspended particles. Such large particles include mite and roach allergen, pollen, and many mold spores. Air cleaners will prove most effective when the particles being removed include a large persistently airborne (or very slow-settling) fraction; pet dander and smaller mold spores might fall in this category. The effectiveness of air cleaners in such cases will be determined by the distribution of the person's exposure between the persistently airborne and the re-suspended particles.

ETS -- with a mean size below 1 m -- represents a special case. The particle size of this aerosol suggests that it could be a candidate for exposure reduction using a flow-through air cleaner. However, because the aerosol consists largely of semi-volatile organics that may continually transform between "solid" and gaseous form, captured "particles" may volatilize and escape, possibly limiting the effectiveness of an air cleaner.

In cases where flow-through air cleaners do appear to offer potential, it is important that the flow rate be sufficient to treat the space. For a typical residential room, for example, a free-standing air cleaner should have a capacity of perhaps 300 cfm.

Ionizing air cleaners use an electric corona wire inside the unit to ionize constituents in the air. These ions migrate into the room and attach to airborne particles, charging them. The charged particles then

attach to surfaces such as walls, or attach to each other and settle, thereby removing the particles from the air. However, it is unlikely that the ion field can extend far enough into a room with sufficient strength to have an effect on all particles. In addition, due to charging limitations, this method will only work for fine particles of about 1 m or less, which is smaller than the primary allergens of concern for asthma. Even with 1 m particles, the charging/settling mechanism is too slow to cause re-suspended in the "personal dust cloud" to settle before they are inhaled.

2.3.5 What are the Best Ways to Manage Fungal Allergens? (Richard Shaughnessy - University of Tulsa)

Many messages regarding biological contaminants exist, including false messages from private service providers and others with a vested interest in certain methods for managing these allergens. In addition to discussing the most effective methods of control, EPA must also address these false messages, which often advocate quick fixes for problems. It is important to make it understood that the control of biological contaminants relates to the control of moisture and cannot be solved simply by placing an ozone generator in the room.

Fungi require water (moisture), food, oxygen, and a warm temperature to grow. The only one of these items that can really be controlled effectively is moisture. Moisture enters a building through wind-driven rain and snow, groundwater, vapor migration and condensation, and capillary action through the slab. Uncontrolled airflow in buildings is often a cause of moisture entering the building. However, pressure conditions can be modified through the HVAC system to avoid this. It is important to prevent flooding, fix leaks, address moisture in the building envelope, and keep the relative humidity at less than 60 percent. It is also important to consider moisture control in conjunction with other remedies for indoor air quality problems. For example, ventilation is often stressed as a solution for indoor-air problems. Yet in a warm, humid climate, bringing outdoor air into a building will make it impossible to maintain a low relative humidity.

Existing contamination can be addressed in a variety of ways. During an investigation, it is important to take care not to exacerbate a problem by disturbing non-aerosolized biocontaminants. Materials that are wet must be dried within 24-48 hours; those that are porous must be discarded if they cannot be cleaned and dried within that time span. Methods to clean up water must not add to it; for example, the use of sandbags to soak up water can provide another ideal home for fungal growth. Flat roofs often leak, which is a source for contamination, particularly for types of fungi that need continuous water to grow. Carpets, even if properly cleaned, can still be a reservoir for fungi; if maintenance is a problem, replacement with hard flooring is best.

HVAC components are a common source of problems. Filters must be kept clean and dry in order to function properly. Drain pans must be kept clean so that they can drain. Porous insulation should not be used downstream from a drain pan or other persistently wet areas of the HVAC system. Insulation can be wrapped in foil facing or other material with a smooth surface to avoid fungal growth from moisture-laden air coming through HVAC coils.

Extensive testing to assess biological problems is not necessary in most cases. To differentiate fungi from dirt, a piece of tape can be used to lift the materials for examination under a microscope; further identification and testing is often not needed. The presence of visible mold may be the best surrogate

indicator of potential exposure that can be used by practitioners to estimate risk, since there is no clear dose-response relationship at this time to assess asthma risk. No numeric criteria exist for interpreting data on biological agents from either source or air samples. In addition, there are many complications with respect to sampling, such as how many samples are necessary, the effects of indoor and outdoor air concentrations, cost, difficulty in interpretation, and the usefulness of the information given the lack of health-based guidelines or consensus.

In general, if contamination is visible, it should be mitigated. The ACGIH recently released its revision of the 1989 guidelines for bioaerosol assessment and control, which can be ordered through their web site at http://www.acgih.org. Minimal personal protection is needed if mitigating biologicals covering less than 0.3 meter. However, if coverage is more extensive, abatement workers should wear full body cover and respiratory devices, and negative pressure should be maintained in the work space.

Ultraviolet light has been proposed as a mitigation method. However, while benefits exist, drawbacks appear to be greater. Though lamps are more powerful than before, they have not been found to be effective on surface contamination outside the immediate area of their use. In addition, spores are more resistant to UV.

Many research questions exist in this area. One is to improve on ventilation, dehumidification, and other moisture-control techniques to make them more affordable. Moisture-resistant building materials should be investigated. Finally, the end usefulness of building materials with antimicrobial properties is still under question. It is also important for EPA to remain abreast of "new" advances that are misleading, such as ozone necklaces, shoe inserts, pet brushes, and ozone generators called by another name. EPA should educate the public about the myths behind these products by updating the web site regularly.

2.3.6 What are the Risk Management Options for Airborne Contaminants? (Bruce Henschel - ORD)

Persistent airborne contaminants include gaseous compounds and particulates of sub-micron size. Examples are VOCs (largely originating indoors), ozone (largely from outdoors), ETS, and aerosols from combustion sources. These contaminants can enhance or trigger an asthma response, even if they are not asthma-inducing allergens themselves. Three methods exist for managing these types of contaminants: ventilation, air cleaning, and source management.-

Increased ventilation to control airborne contaminants is applicable only when the outdoor air is not the primary source of the contaminant. Ventilation serves to dilute the indoor air with outdoor air. It will provide about a 50 percent reduction in contaminants by doubling the vent rate or 75 percent by quadrupling the rate. Greater reductions are possible when exhaust ventilation can be used to avoid pollutant dispersion from localized sources through pressure adjustment. For asthmatics, increased ventilation will probably be useful primarily in providing short-term relief under particular circumstances, such as during painting.

Flow-through air cleaners for gaseous contaminants rely on sorption, either through physical adsorption (e.g., on activated carbon) or chemical absorption (e.g., on impregnated alumina).

However, they are not sufficiently well demonstrated to be recommended by EPA for residential indoor-air applications. Their long-term performance indoors is unclear on time-varying concentrations of contaminants. They require a mass of sorbent and/or a frequency of sorbent replacement that may be greater than can be implemented practically in the home.

Ozone generators claim effectiveness in removing a variety of gaseous contaminants; some also include ionizers and claim particle removal as well. However, ozone itself enhances asthma symptoms. While many generators have controls to limit ozone concentrations to "safe" levels, these controls can be turned off, and measure ozone from the back of the unit, not in the front where the concentration is the highest. At levels below the National Ambient Air Quality Standard (NAAQS) of 0.08 ppm over eight hours, ozone is generally not effective in removing VOCs, and when reaction does occur, undesirable by-products are commonly formed. At these levels, ozone is not effective in killing molds, viruses, and bacteria. The extent to which ozone at these levels inhibits mold growth and spore formation (without actually killing the organisms) is unclear, and no data exist to support claims that mite allergens or carcasses would be oxidized. Because ozone can be harmful to health, and because there do not appear to be clear benefits from using ozone generators, EPA does not recommend the use of these devices.

Source management is considered at this time to be the most effective method of decreasing indoor air quality problems. Removal of products that emit contaminants, such as carpet, and replacement with low-emitting construction materials and furnishings, or materials resistant to bio-contamination, is recommended. Stopping the use of cigarettes and fireplaces will reduce contaminants. Relocating the source, such as solvents, smoking, or pets, outdoors is recommended. Treating the source, by encapsulating duct liners and washing pets regularly, and controlling building conditions by reducing relative humidity can be effective. Finally, controlling occupancy patterns and simply having asthmatics stay away during solvent use, vacuuming, or other potential situations for exposure, is also an effective means of managing contamination. Research on source management to control indoor air contaminants is being conducted at EPA's NRMRL. Work is being done to characterize emissions from indoor sources, including low-emitting substitutes; to promote development of low-emitting substitutes; and to develop standardized test methods to assist industry in verifying low emissions from indoor products.

2.4 Information Issues

2.4.1 Where Can We Find Science Information on Asthma? (Lisa Ryan - ORD)

EPA is developing a new web site on asthma science, which will present scientific information on asthma, including research activities, a discussion forum (both for discussion within EPA and with the public), and links to other sites, databases, and conferences. It will also include contacts for asthma research and programs in all areas of EPA, including labs and Regional offices. The web site will be available in Fall 1999. Workshop participants suggested that coordinated journal subscriptions and library facilities, as well as Intranet group subscriptions to *Environmental Health Perspectives* and other journals, would be helpful for faster medical research.

EPA Region 3 shared its web site, which has a feature called EnviroSnax that gives fast facts on an issue of concern. For example, it discusses how asthma is high among homeless children and how

asthma-related deaths have increased in most states between 1990 and 1995, although days in which air quality exceeds EPA standards are decreasing.

Workshop participants also discussed general issues that arose over the course of the workshop. Science information is important to use in influencing management to devote resources to asthma. It is important to identify the problem clearly and define its extent and demographic impact in a particular area by comparing it with other areas through epidemiology. A particular project should emphasize what potential causes of asthma it intends to address, how long the solution will take to implement, and at what cost. Performance measures, including a definition of success and means of measuring it, are important. Such measures can be linked to the goals EPA established under the Government Performance Results Act. Finally, partners and their methods of support should be identified.

In presentations to management and the public, main points and issues should be outlined with bullets. Graphics and color also help emphasize points.

For example, the following points were taken from a chapter in a book entitled, "The Rising Prevalence and Severity of Asthma in Western Society: Are the Causes of Asthma the Causes of the Increase?" by Thomas A. E. Platts-Mills et al. In: Asthma: Causes and Mechanisms of an Epidemic Inflammatory Disease. 1999. CRC Press LLC, Boca Raton, FL. These were overlayed on a map of the world, emphasizing that asthma is a world-wide problem.

- A progressive increase in the number of asthma cases has been seen since 1980, in both children under four years and adults.

- While molds may be associated, cases are also documented in dry areas in which dust mites and molds are not relevant.

- Asthma is most common in "civilized" areas and is rare in societies lacking electricity and cars.

3. Discussions

After each set of presentations, participants were asked to write down the most interesting or surprising facts they learned from the presentations and their opinions on what questions still remained to be researched. These responses were compiled into lists. During breakout sessions, participants used these lists to develop an overall list of priority knowledge gaps. They also listed actions that can be taken by the Regions to enhance the effectiveness of their community asthma work, based on the knowledge taken from the workshop. Finally, staff from the Regions and program offices provided an evaluation of the workshop and suggestions for future meetings. ORD staff developed a list of follow-up commitments they can enact in order to support asthma work in the Regions and program offices. Transcripts of participant responses and flip charts from the breakout sessions are provided as Appendix B. Comments have been summarized below.

3.1 Question 1—What was the most useful new knowledge you gained at the workshop?

Participants came to the workshop with varying levels of existing knowledge about asthma. In many cases, the most interesting new information was how much is still not known about asthma. Many were surprised at the large number of factors that must be considered when examining asthma incidence and severity. In addition, while a variety of asthma triggers have been identified, the cause of the increase in asthma incidence is not known, although it is most likely some combination of environmental, immunologic, and genetic factors.

While the incidence and severity of asthma have been increasing over the last ten years, the cause of this is still unknown. The increases appear to be the greatest in clean, urban, industrialized societies with a wide use of electricity, traffic, and time spent indoors. Increases appear to be greater in the Northeast than in other parts of the United States. This is particularly evident when looking at the differences between asthma in Puerto Ricans living in the Northeast and other Hispanic groups living elsewhere.

Air pollution, long considered important in conjunction with asthma, appears to play a more complex role than previously thought by many participants. The interaction between air pollution and other asthma triggers and allergens may be more significant than exposure to air pollutants alone. The particular role of auto emissions and VOCs was noted, as was the difference between indoor and outdoor air exposures.

Workshop participants were also interested in the difficulties in measuring contaminants in the field, particularly biologicals, both in terms of research and intervention. In addition, once the level of contamination with a particular source is known, the relation between that source and a case of asthma is not necessarily evident. This can lead to frustration on the part of the public, who have anecdotal experience with exposures, such as to molds, but the data from the scientific community establishing causal links and threshold levels do not exist.

Finally, participants gained new knowledge about mitigation and risk-management techniques. Ventilation, air cleaning, and source control are all methods of control. However, each has its own positive aspects and drawbacks. Ventilation may make source (moisture) control more difficult in some

climates. Many different air cleaners exist, and there is no single air cleaner that will effectively address all types of indoor-air sources. While many techniques exist to reduce allergen sources, such as pest management and moisture control, these interventions do not always lead to clinical effects.

3.2 Question 2—What are the most significant gaps in our knowledge important to assessing and mitigating asthma problems?

Obviously, the most significant data gap is in identifying the initial cause of asthma, or interaction between several causal factors, and consequently a means of asthma prevention. Other gaps lie in determining the reason for differences in asthma incidence and severity between the present and one decade ago, as well as differences that exist now. For example, incidence and severity in the Northeast vs. the rest of the country, residents of urban industrialized areas in tropical climates vs. cold climates, and other ethnic, genetic, social, and environmental factors should be investigated.

In general, it is necessary to isolate pollutants and their relationships with regard to asthma sensitization and severity. Dose-response relationships should be determined for prevention and mitigation. In addition to those sources that cause or exacerbate asthma, research should be done into those factors which appear to be protective, such as orange juice/antioxidants and outdoor exercise.

Several participants identified the need for more data on a state and local level. An asthma registry which could be used in association with GIS applications was suggested as a means of looking for patterns in the location of cases within smaller units, such as towns. It is also necessary to understand asthma at different points in the life cycle, from neonatal exposures, to childhood asthma, to children who outgrow it, to adults who suffer from asthma.

In particular, workshop participants emphasized the need to continue considering the role of air pollution. While air pollution, in terms of long-term averages regulated by the NAAQS, has decreased at the same time asthma incidence has increased, other air pollutants should be considered. These include air toxics in short-term concentrations, the role of auto emissions, and the interaction between air pollutants and other asthma triggers and allergens.

Research regarding indoor air should be continued, particularly considering the effects of low levels of chemicals, pesticides, VOCs, and biologicals. While mold exposure is associated with asthma anecdotally, more research should be done on the mechanism of mold exposure and asthma. For example, which molds are more allergenic, and is it exposures to spores or particular toxins produced by the molds that are harmful? What is the role of concomitant exposures in cumulative risk? What is the relationship between indoor and outdoor exposures? Are there differences, in either asthma rates or exposures between different indoor environments, such as homes, schools, and offices?

Easy-to-use, cost-effective methods of measuring environmental contaminants are lacking. However, even if they existed, thresholds for sensitization or triggering must be determined. Finally, while risk management techniques are known, they require further study on ways to make them more clinically effective. Risk management must also be customized for real-world situations, such as those associated with low incomes, tropical climates, or particularly cold climates. Finally, this knowledge

must be communicated to the public, who are inundated with conflicting information from those with a vested interest in particular sources or mitigation methods.

In summary, data on threshold exposures necessary to trigger a response would enable the setting of standards or guidelines for diagnosis and remediation. Other complex issues require more consideration, such as interactions between the various contaminants a person is exposed to at one time in the real world. Likewise, mitigation strategies are generally known, such as to control moisture, but these strategies need to be considered in real-world settings. Low-income families or those in humid climates may have difficulty implementing general control strategies that have not been tailored to their unique situations.

3.3 Question 3—With the knowledge from the workshop, what additional actions can the Regions take to enhance the effectiveness of their community asthma work?

Since the causes and triggers of asthma appear to be linked to a range of factors, it is important to ensure that EPA efforts related to each of those factors also be related. For example, indoor and outdoor air programs, particularly out of IED and the Office of Air Quality and Planning Standards (OAQPS), must be linked within Headquarters and subsequently within the Regions. Regional offices can work with ORD to identify candidates for community-specific pilots for both causation and intervention studies.

Links on a Regional level should also be established with counterparts outside EPA, such as State and local health departments and Federal agencies such as HHS and NIOSH. Work with state and local entities should include increased local surveillance and possibly an asthma registry. This would help identify particular communities or parts of communities affected by asthma, whose exposures could be studied, as well as the effectiveness of targeted interventions.

Finally, Regions must work to ensure that the public understands the complexity of the asthma issue and that no “quick fixes” exist at this time. Educational outreach must address the conflicting messages sent by others with a vested interest in the issue. Outreach should address potential causes and triggers as well as effective mitigation techniques. Such efforts must be comprehensive and discuss <u>all</u> sources, including outdoor, indoor, and occupational sources, and their interactions.

4. Wrap-Up

4.1 Workshop Evaluation by Regions and Programs

Regional and program staff thought that the workshop provided a comprehensive focus on an important topic. They enjoyed the opportunity to meet their counterparts around the country and network with one another and ORD staff. The random assignment to breakout discussion groups encouraged this interaction. Presentations by both scientists and program staff allowed each participant to gain an understanding of the breadth of EPA activity on the asthma issue. By keeping the workshop restricted to EPA staff, with the exception of limited outside speakers, information could be shared and discussed freely without concern for outside influence or interpretations of EPA policy. Participants thought that the organization of the workshop into sessions designed to address particular questions was effective, although they recommended that questions be more tailored to particular programs in the future. Finally, they commended ending the presentations with a demonstration of the forthcoming asthma science web site, which is a concrete product that will facilitate workshop follow up by providing a forum for discussion.

Regional and program staff suggested that a copy of the video made of the workshop proceedings be provided to relevant program offices and each region. They thought that the workshop should be repeated every two years, rotating the site among different regions, laboratories, and headquarters, and that continued information and technical transfer be encouraged. In the future, more time should be allotted for discussion, and agenda questions should be tailored to apply to particular EPA programs. More comprehensive pre-meeting materials, including background information as well as copies of presentation overheads, would be useful. More emphasis should be placed on topics dealing with the effects of indoor exposures and on outdoor mitigation.

EPA-wide involvement in the asthma issue is necessary. Regional and program staff suggested that ORD become more involved in IED strategy meetings and include other non-IED staff in special asthma sessions. They also suggested linking indoor and outdoor air projects with regard to asthma and asked that more OAQPS staff be included in the future. Participants wished to see more presentations and posters from the Regions and program offices, with abstracts on the project available for ORD staff. More Regional participation could be achieved by providing financial assistance to those wishing to travel to a future workshop.

4.2 ORD Follow-up Commitments

ORD staff met at the conclusion of the workshop to discuss ways in which they can further support the Regional and program offices in their asthma-related work. In general, suggestions centered around maintaining open lines of communication between ORD scientists and Regional and program staff. ORD can serve as a resource to Regional scientists working on asthma issues. In addition to communication on an individual basis by telephone or electronic mail, ORD scientists can make visits to the Regional offices and brief staff, particularly when working on an ORD asthma research project in the Region. ORD can also support the forthcoming asthma science web site by posting relevant research findings and products and updating it regularly. Use of the web site as an effective means of

distributing information around EPA and for conducting focused, internal discussions should be encouraged through regular updates. Finally, EPA should work with Regional staff to leverage community-based ORD projects in the Regions. The Regions can provide information on appropriate locations for community-based research and in many cases have already established a contact base in a community from previous activities.

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June 15-17, 1999

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Appendix B: Agenda

ASTHMA: THE REGIONAL SCIENCE ISSUES
June 15-17, 1999 Washington, D.C.

FINAL AGENDA

JUNE 15

SESSION 1: INTRODUCTION

8:30 - 9:15
What will this workshop accomplish?
- "New Directions"with the EPA Regions - Hugh McKinnon, Deputy AA for Science/ORD
- The EPA Focus - Bob Axelrad, Office of Children's Health Protection/OA

9:15 - 9:45
Introductions and Approach to Achieving Workshop Objectives *[30 min.]*

9:45 - 10:00 Break

SESSION 2: EFFECTS & EXPOSURE ISSUES (leads: Hillel Koren/ORD & Barbara Spark/Region 9)

10:00 - 11:00 *[45 min. presentation , 15 min. interaction time]*
What are the basic aspects of asthma? - Hillel Koren/ORD
- Biology, physiology, pathology, heterogeneity, and genetics of the disease

11:00 - 12:00 *[45 min. presentation, 15 min. interaction time]*
How are environmental factors linked to asthma? - Lucas Neas/ORD
- Epidemiologic studies of the prevalence and exacerbation of asthma
- Role of allergens, fungi, viruses, and air pollutants in the causation of asthma
- Role of air pollutants in the exacerbation of asthma

12:00 - 1:00 **Lunch**

1:00 - 2:00 *[10 min. presentations by each panel member, 20 min. discussion]*
What is ORD's role in the larger Federal context?

- ORD- Hillel Koren
- NIH - Marshall Plaut (Inner City Study)
- CDC - David Mannino
- NIOSH - Mike Hodgson

2:00 - 3:00 *[1 hr. of hands-on demonstrations]*
***How do we study asthma and environmental factors*?** Hands-on demonstrations of effects and exposure monitoring equipment, i.e.,

- Peak flow & nasal lavage - Lucas Neas/ORD
- Burkard Sampler & dust sampling - Haluk Ozkaynak/ORD

3:00 - 3:15 Break

3:15 - 4:45 *[1 hr. of presentations, 30 min. interaction time]*
What is the role of molds in asthma severity and incidence?

- Molds in homes, schools, and offices - Mike Hodgson /NIOSH
- Issues surrounding research on molds - Barbara Spark/Region 9

6:00 Group Dinner

JUNE 16

SESSION 2 CONTINUED

8:30 - 8:45
Group Check-In

8:45 - 9:15 *[20 min. presentation, 10 min. interaction time]*
What are the interactions between air pollutants and allergens? - Howard Kehrl/ORD

- Clinical and toxicological studies of the interactions of pollutants and allergens
- Role of air pollutants in the sensitivity to allergens
- Role of air pollutants in the development of sensitization to new allergens

9:15 - 10:00 *[30 min. of presentations, 15 min. interaction time]*
How does one assess exposures to environmental contaminants related to asthma?

- Bioaerosols - Steve Vesper, ORD
- Chemicals: Lance Wallace, ORD

10:00 - 10:30 GROUP DISCUSSIONS ON SESSION 2 ISSUES

10:30 - 10:45 Break

SESSION 3: RISK EVALUATION ISSUES (leads: Sue McMaster/ORD & Mary Beth Smuts/Region 1)

10:45 - 11:30 *[20 min. presentation; 25 min. interactive Regional discussion]*
What risk questions are communities asking?
- Community asthma case studies - Mary Beth Smuts/Region 1
- ***Regional Round Table on Community Asthma Issues***

11:30 - 12:30 *[40 min. of presentations, 20 min. interaction time]*
What test methods and guidelines exist to evaluate the risks from exposures to asthmagens?
- Current risk assessment approaches for environmental respiratory allergens - Mark Greenberg/ORD
- Test methods and guidelines - Mary Jane Selgrade/ORD

12:30 - 1:30 Lunch

1:30 - 2:30 *[40 min. of presentations, 20 min. interaction time]*
- Evaluation of potential causes - David Mannino/CDC & Lucas Neas/ORD
- Air pollution and asthma: assessment approaches - Larry Folinsbee/ORD)

2:30 - 3:00 GROUP DISCUSSIONS ON SESSION 3 ISSUES

3:00 - 3:15 Break

SESSION 4: RISK MANAGEMENT ISSUES (leads: Bruce Henschel/ORD & Rachel Chaput/Region 2)

3:15 - 3:30 *[10 min. presentation, 5 min. interaction time]*
How do we determine appropriate mitigation approaches? - Bruce Henschel/ORD
- Mitigation options and performance
- Available guidance
- EPA research

3:30 - 4:15 *[30 min. presentation, 15 min. interaction time]*
What are some practical approaches for managing cockroach and pet allergens?- Rachel Chaput/Region 2

4:15 - 4:45 *[20 min. presentation, 10 min. interaction time]*
What works/doesn't work in reducing exposures to dust mite allergens? - Bruce Henschel

JUNE 17

8:15 - 8:30
Group Check-In

SESSION 4 CONTINUED

8:30 - 9:00 *[20 min. presentation, 10 min. interaction time]*
What is the role of particle air cleaners for asthma risk management? - Bruce Henschel/ORD

9:00 - 9:30 *[20 min. presentation, 10 min interaction time]*
What are the best ways to manage fungal allergens? - Richard Shaughnessy/contractor

9:30 - 10:00 *[20 min. presentation, 10 min. interaction time]*
What are the risk management options for airborne contaminants? - Bruce Henschel
- ETS
- Gaseous enhancers/triggers (formaldehyde, O_3, etc.)
- Control approaches specific to airborne species (e.g., air cleaners)

10:00 - 10:30 GROUP DISCUSSIONS ON SESSION 4 ISSUES

10:30 - 10:45 Break

SESSION 5: INFORMATION ISSUES (lead: Lisa Ryan/ORD)

10:45 - 12:00 *[25 min. presentation, 20 min. interaction time]*
Where can we find science information on asthma?- Lisa Ryan
-Asthma web site demonstration
- List server
- Information briefing packages for Regional management and public fact sheets

SESSION 6: CONCLUSIONS and NEXT STEPS

12:00 - 1:00 *[30 min. break out, 30 min. plenary]*
- What was the most useful new knowledge you gained at the workshop?
- What are the most significant gaps in our knowledge important to assessing and mitigating asthma problems, and
- With the knowledge from the workshop, what additional actions can the Regions take to enhance the effectiveness of their community asthma work?

Appendix C

Transcript of Flip Charts and Comment Cards

Appendix C

REGIONAL SCIENCE—ASTHMA WORKSHOP
U.S. Environmental Protection Agency
June 15-17, 1999

Question 1: What was the most useful new knowledge you gained at the workshop?

SESSION 2 (Effects and Exposure), June 15 (morning)

? The number of factors which impact incidence of asthma is large.
? Drugs only impact a few types.
? Air pollution is associated with exacerbation but not prevalence of asthma.
? Childhood asthma is primarily extrinsic.
? Asthma is a complex disease that is probably not from one entity.
? Many factors influence asthma, including environment, genetics, and infection.
? We don't have a clue as to why the incidence of asthma is increasing. A few studies link it to air pollution but most do not. However, air pollution does seem to increase asthma symptoms.
? Extrinsic/intrinsic clarification is striking.
? Asthma is the result of clean, urban, advanced industrial societies.
? Asthma is an immunological disease.
? T helper 2 cells drive asthma.
? PEF is a good tool to diagnose airway resistance.
? Individual vs. group data (research exists on individual level) is striking.
? What induces/exacerbates asthma is important.
? Economic impact of asthma is significant.
? There is a cascade of cellular events that results in asthma.
? The number of asthma deaths per year is striking.
? Particulate matter and ozone do not cause new cases of asthma.
• The large amount of cellular change/involvement within the lung tissue is interesting.
? The use of inhaled and oral corticosteroids to reduce inflammation of lung tissue and how steroids allow realignment of cellular structure towards the normal is interesting.
? The equipment for diagnosing respiratory problems is noteworthy.
? Physiology of asthma is interesting.
? Mucus plug and other visuals were interesting.

June 15 (afternoon)

• Percentage of asthma cases related to genetic factors is interesting.
• Ability of the peak flow meter to predict onset of asthma attacks.
• The alarming increase in rates of asthma afflictions among children, yet the NAAQs are falling (almost uniformly)—most likely due to living characteristics.

- "Cleaner environments" (e.g. New South Wales, Australia) are associated with higher asthma rates.
- The CDC budget to research asthma is $0.
- Passion in closing speech and obvious concern about the relationship between fungi and asthma/respiratory illnesses.
- Difficulties encountered by researchers studying fungal epidemiology.
- There is a possibility that molds may not trigger/cause asthma.
- There are geographical variations in the incidence of asthma.
- The interesting discussion regarding genetics and immunology and the reflection these factors have on asthma.
- The actual discrepancy in asthma mortality between Puerto Ricans and other Hispanics.
- The increased mortality rate due to asthma in the Northeast sections of the United States, and the severity differences between the Northeast and Western U.S.
- The fact that mold research is actually not very advanced.
- Criteria air pollutants don't actually increase the prevalence of asthma attacks.
- The description of sputum and nasal lavage demonstrations.

? New advances in mycology and air sampling are encouraging.

? Measurement of molds is difficult and little is known on the subject.

? Discussion of the analysis of biologicals was interesting.

? Pollutant/allergen exposures shown to be a problem, but be aware that exacerbation of asthma does not imply causation of asthma.

? More information needed on prevention.

June 16 (morning)

- New technologies are being developed to identify fungal species from dust samples.
- There is difficulty with the ability to tell the differences among types of fungi that are present indoors by visual inspection. But DNA sequencing analysis can differentiate fungal contaminants. This has the potential to be used to understand which fungi cause most indoor air problems.
- The relative insignificance of outdoor contributions to indoor exposures was noteworthy.
- It is surprising that there is still such a large quantity of banned air toxics in homes, e.g. DDT.
- It is noteworthy that benzene leaks into a house from an attached garage.
- The relationship between indoor and outdoor exposures is surprising.
- The technology used to sequence and identify fungi is impressive.
- The group now has a better understanding of the difficulties associated with visual inspection of fungi in samples.
- The information about carbon tetrachloride and vacuum cleaner efficiency was surprising.
- The persistence of certain compounds (carbon tetrachloride, DDT) in a house is surprising; it is also surprising that these compounds appear to come mainly from outside of the house and remain a problem.

- It is noteworthy that outside concentrations are used as a baseline for indoor exposures to pollutants.
- The chemical assay (PCR) for fungal spores was interesting.
- The mobilization of household dust by vacuuming was noteworthy.
- The significance of the differences between indoor and outdoor exposures is important.
- The information on how to identify microbial samples was useful.
- The VOC emissions in Elizabeth-Bayonne, NJ were surprising.
- It was surprising to learn that pesticides that were banned 15 years ago are still present in and around homes.
- It was noteworthy that there were no EPA panel studies in NJ supported by NERL.
- The new technology for measuring fungi in samples is very interesting. Will this technology finally show that fungi are important causes of asthma?
- The progress made in developing technologies to identify and measure fungi is impressive.
- It was useful for those who are not involved with fungal measurements to understand the methodology used.
- It was interesting that it took less allergen to elicit a nasal response following ozone exposure than to elicit a nasal response without an ozone exposure.
- It was surprising that: (1) air monitors do not pick up ultrafine particles; (2) they are not placed at ground level where they would pick up automobile pollution; and (3) automobile pollution may affect asthma rates.
- The mechanism of asthma does not depend on IgE.
- Intrinsic asthma has no known mechanism.

SESSIONS 3 and first part of 4 (Risk Evaluation and first part of Risk Management), June 16 (afternoon)

- It was interesting to hear that SO_2 has been well studied and is related to asthma.
- The high cost associated with animal testing of one chemical for allergic and/or asthmatic endpoints.
- ORD research on microbial pesticides and their role in asthma.
- Prenatal exposures to allergens actually increase the prevalence of asthma in children.
- The role of diesel particles in the development of sensitivity to antigens.
- Some people actually wash their cat!!!
- Store bed linens in the freezer to reduce the existence of dust mites.
- There were very informative overviews of HDMs and cockroaches. Information was provided regarding the quite overlooked aspect of de-naturing. It was also useful to hear about the ineffectiveness of Allerpet.
- There is a vast extent of allergies to which people react.
- The tremendous difficulty regarding the elimination of allergies.

June 17 (morning)

? Ozone generators do not work well for <u>anything</u>, particularly fungi.

? Relative humidity is difficult to control to same levels in room and on surfaces.

- ? Abatement of molds and fungi can actually exacerbate the problem if not done correctly.
- ? Types of air cleaners most effective for different air contaminants.
- ? New ACGIH guidance does not recognize any standards or numbers for the interpretation of measured fungal levels.

Question 2: What are the most significant gaps in our knowledge important to assessing and mitigating asthma problems?

SESSION 2 (Effects and Exposure), June 15 (morning)

- ? Need improvement of knowledge regarding biology, incidence, and causes of asthma.
- ? What is it about urban areas that impacts incidence of asthma?
- ? Can we prevent a child from becoming asthmatic? What are most important allergens?
- ? Inner City Asthma: Have we characterized exposures to chemicals, allergens, etc., in a quantified way in homes of asthmatic children, looking for correlations between exposures and expression of disease over time? Isolated the pollutants that are of most importance in asthma sensitization and expression of disease for risk management? Relationship between exposures and disease severity?
- ? JHU Study of Inner City asthma in cooperation with Baltimore Housing Authority, USDA/ARS, FDA is attempting to remove children (ten subjects) from cockroach infested housing to housing that is completely free of cockroaches and allergens to measure impact on asthma occurrence and severity. The study will quantify cockroach and allergens before move and after move. The study has major funding from NIH. Would ORD have an interest in reviewing study proposal and possibly participating (Steve Williams)?
- ? What is causing the increase of asthma? What are the risk factors?
- ? What percent of asthma is due to xenobiotics (chemicals and pesticides)?
- ? What is the mechanism of orange juice protectiveness and protectiveness of outdoor exercise?
- ? There is a need for a better understanding of early events in neonates and young children that drive towards asthma.
- ? Why is there an outgrowth in late adolescence?
- ? Statistics on the amount of time children spend outdoors vs. indoors.
- ? Actual exposures: air sampling layer stratification.
- ? Intrinsic vs. extrinsic asthmagens.
- ? Better understanding of prevention techniques.
- ? What is the incidence of asthma in large cities in developing countries like Bombay, Jakarta, Bangkok, Beijing, etc.?
- ? How is a “cleaner” environment defined? Strictly by industrial development? GDP?
- ? Why is there a sex difference in asthma prevalence? (More asthmatic women than men in all age groups, but perhaps different outcomes between women and men exist in specific age groups.)
- ? With the exception of ozone and carbon monoxide, NAAQS are long-term standards (8 hour, 24 hour, annual average). Is it possible that short-term concentrations of pollutants like sulfur dioxide, nitrogen dioxide and particulate matter may cause or exacerbate asthma? Is existing air

pollution data appropriate to make conclusions about association between asthma and air pollution?

? There is a need for development of more air monitoring equipment that allows short-term averaging times (i.e. more continuous monitoring technologies).
? How do we know asthma is increasing (what studies)?
? How do we know asthma is increasing faster in minorities (what studies)?
? Understanding importance of indoor vs. outdoor exercise.
? How do we know the true incidence of asthma?
? Data on the onset of asthma after being exposed to a moldy environment as an infant.
? Contribution of diesel emissions.
? Data on rural vs. urban asthma increases.
? Different urban sizes vs. asthma increase.
? Summary information for regional use?
? To what extent do children of all ages differ from adults, immunologically?
? Prevention of new cases of asthma.
? Improved control for existing asthmatics.
? Environmental factors contributing to asthma—new cases and triggering episodes in existing asthmatics.
? Like the idea of a registry—this can overlay with GIS information to improve understanding.
? Causes of asthma and/or determine severity by studying adults who were asthmatics as children and either do or do not have symptoms as adults?
? Where do we find morbidity data?
? No registry of asthma cases (don't know if there is a problem in the community).
? Outdoor versus indoor, tropical climate versus northeastern, in particular.
? How to identify pre-asthmatics—early onset.
? Uncertainty of why asthma incidence has increased.
? No one is looking at tropical climates.
? There is a lack of integrated exposure assessment between allergens, pollutants, and climate.
? Need better information on indoor sources. What are the chemicals and their sources of exposure associated with asthma?
? Do outdoor air toxins increase the rate of asthma? What about studies in New South Wales, Australia, where there is low pollution, but increased asthma rates?
? Can asthma be managed well by drugs? What are the long-term side effects?
? Need more information on stress-related asthma attacks—intrinsic or extrinsic?
? Need better location-specific asthma data from the U.S. Department of Health and Human Services.
? Need more data on non-immunologic asthma and on biologic markers of effect, not exposure.
? Need to know best placement for air monitors—how accurately do they reflect population exposure?
? Once a person is sensitized and has asthma, can exposure to an air toxic by itself induce an asthma attack?

? Need more work done to measure relative contribution of manufacturing sources to exposure to air toxics.
? Age, race, and gender as factors in asthma genesis.
? Research concomitant exposures rather than single exposures—for example, benzene exposure at 10 am, BLAG1 (cockroach antigen) at 2 pm, and PERC and HDM at 5 pm.
? Research on low level chemical exposures and asthma.
? Require more information on risk management and outreach.
? What are pre-asthmatic conditions?
? What affects the severity of asthma?

June 15 (afternoon)

- Need for more in-depth studies on the influence of genetics.
- The relation of both indoor and outdoor air on the prevalence and severity of asthma in children.
- More case-specific data on asthma.
- The tremendous gaps in research on both the causes and exacerbations of asthma attacks.
- The need for many more tests on the existing hypothesis related to the causes of asthma, or conduct a mega-review of the asthma epidemic.
- The role air toxins—VOCs—play in asthma etiology and exacerbation.
- The lack of information on the role of ultrafine particulate material.
- Lack of epidemiology and basic research in animal models on the topic of bioaerosols and mold.
- Lack of integration of exposure to allergens and air pollutants with genetics and the clinical outcomes of these types of situations.
- How does this disease occur?
- Is there really an association between exposure to toxins, such as air pollutants, and allergic sensitization?
- Due to the large number of intervention studies currently being performed , the most effective intervention should be clearly understood soon.
- There is a need for an increase of data collection by State and local agencies.
- Development of easy to use, cost-effective methods to measure environmental contaminants that possibly could be increasing the incidence of asthma.
- What can the EPA do to convince management to support an increased outreach effort?
- What do we know about the exposure to pesticides and all the other chemicals in foods in relation to the increased prevalence of asthma.
- More cause and effect data is needed in regards to molds.
- Does an age trend exist with regards to the increased incidence of asthma in children, and if so, at what age does the incidence increase?
- Look at facts regarding asthma attacks, such as: time of day, time of year, indoor vs. outdoor, indoor: home vs. school.
- Research the existence of a time lag between exposure to triggers and the event of an actual asthma attack.

- Research the percentage of asthma cases due to genes vs. the percentage due to environmental triggers. And of these environmental triggers, what part is due to indoor vs. outdoor exposures?
- A mitigation measure that actually works to reduce the exposure to indoor asthma triggers is a serious data gap.
- A missing point in the research on molds and bioaerosols is a clear link between the two and asthma attacks.
- Effects of air toxins on the prevalence of asthma cases.
- To what extent have the indoor/outdoor factors been studied in the tropical environments/ climates? Citizens in tropical (e.g. Puerto Rico, Virgin Islands) areas claim that indoor air is not as important in their environment due to amount of time actually spent outdoors (which in this culture is more than time spent indoors). This population also relies more on natural ventilation (instead of air conditioning, for example) and uses different construction materials (e.g., less carpet, more concrete). These factors should be considered and contrasted to the continental U.S. in regards to the prevalence of asthma.
- There is a lack of data regarding the prevalence and morbidity rates due to asthma in Puerto Rico and the Virgin Islands.

? Mitigation of sources—what really works?
? Causal relationship between fungi and asthma is still lacking.
? Can we prioritize air toxins/molds/criteria pollutants and other triggers for future research?
? Can we prioritize intervention strategies for future research?
? Need to develop simple, cheap, and easy-to-use methods of measuring mold.
? Need to know how to use new sampling analysis of dust and other types of air samples.

June 16 (morning)

- There is a need to use technology to measure fungi and to combine this with health studies to determine the fungus of greatest concentration.
- There is a need to study further and prepare guidance on the ability of air cleaners to reduce air particles.
- There is a need to identify which molds cause asthma.
- There is a need to know how long a healthy person can live in a moldy environment before having respiratory attacks/asthma.
- More quantitative information about the role of fungi in eliciting asthma symptoms is needed.
- Better modeling/monitoring is needed to describe the penetration of outdoor pollutants to indoor environments.
- There is a need to identify the relative role of pollutants in asthma.
- More research on indoor environments is needed. Perhaps the focus should be on chemicals already associated with asthma.
- The relationship of microbials and chemicals to asthma needs to be studied.
- There is a gap in associating and quantifying mold levels with diseases like asthma. What is the threshold of indoor mold levels that cause disease?
- The effect of VOCs on asthma needs to be addressed. Are areas that are high in VOCs associated with high asthma rates?

- Is there information about indoor/outdoor pollutants in tropic climates?
- What information is available on molds/fungi at tropic climate locations?
- What is the relative relationship (if any) between SO_x in ambient air and asthma?
- There is a need to use new technologies to monitor levels of molds indoors.
- There is a need to compare mold levels with health impacts.
- There is a need to perform interventions for molds and to look at impacts on levels and health symptoms.
- The endotoxin versus spores issue needs some resolution.
- Conduct more studies on how exposure to environmental contaminants, such as bioaerosols, relates to asthma. Be aware of molds.
- Asthma surveillance in regions and localized areas.
- Conduct more research on volatile organic compounds and air toxics and their role in asthma.

SESSIONS 3 and 4 (Risk Evaluation and Risk Management),
June 16 (afternoon)

- A need exists to determine the progress of local, State, regional, and national agencies in regards to studies on the reduction of household/environmental allergens.
- Practical approaches for interventions to reduce allergens.
- Better characterizations of thresholds for sensitization for the variety of allergens.
- We need more practical information on the control of allergens of different sizes.
- A successful integration of pest management tailored for tropical (humid) climates.
- Need to make sure OAQPS, IED, and ORD managers present summary of this meeting to Air Directors as well as Pesticide Managers.
- Interventions into the problems associated with cockroach, pet, and dust mites—to date, information seems to have sketchy results.
- A need exists for proof that mitigation works and is cost-effective.
- Need to develop quick, reliable screens for hazard identification for new chemicals and pesticides (including bio-pesticides).
- Improvement is required to understand which exposures to what environmental agents along with time periods (of exposure) contribute to asthma prevalence.
- Improve understanding of role of air pollutants in regards to allergens and asthma.
- Research the role of the most common indoor air pollutants and their effect on asthma.
- Better understanding of low level chemical exposure risks for asthma.
- Better, more complete understanding of the data concerning the role of pollutants in promoting and/or exacerbating asthma.

June 17 (morning)

? UV germicidal air cleaning systems/effect of UV on fungal spores within a localized area, and/or on viable spores in passing air stream.
? Ionizer health effects issues.
? Better understanding of how to control organics indoors.
? Ways to prevent growth of fungi on materials.

- Information tailored to risk management in climates other than cold, such as tropical climates in the Caribbean.
- Health effects of exposure to ions.

PRIORITY KNOWLEDGE GAPS (across SESSIONS 2, 3, and 4), June 17 (morning)

- What causes asthma and why is it increasing?
- What is the role of air toxics, indoor and outdoor?
- Pesticides—screen with asthma exacerbation as endpoint.
- More data on pesticides and asthma in general.
- Threshold for antigen sensitization response; threshold for asthma attack.
- Look for dose/response triggering data in clinical settings for asthma attack.
- Need much greater emphasis on the collection of data characterizing the contribution of indoor air to the increased incidence of asthma.
- Raise visibility of asthma problem to policy makers.
- Focus on cumulative risk and asthma—mixtures of exposure (bioaerosols +VOCs etc.) and sensitization and triggers.
- Information on effectiveness of novel air "cleaning" systems (other than ozone and UV systems)—which are recommended?
- Lack of asthma prevalence data and local data—work with HHS to increase surveillance.
- Need to access asthma trends data worldwide.
- Need epidemiologic data that is easily understandable.
- Practical intervention—guidelines, look at subpopulations with specific needs such as lower access to resources, data on effectiveness of interventions, how do you measure effectiveness.
- Integrated exposure assessments are needed.
- Laboratory data needed on mitigation techniques.
- Need more information on asthma in tropical environments—risk factors, prevalence, mitigation techniques.
- Need better surveillance data that show asthma data by region and communities, i.e., the South Bronx, Cataño.
- Are schools particularly susceptible?
- Are there environmental aspects which contribute to increasing rates of asthma?
- Need better information on the role of molds.
- Controlled studies to rigorously define how well specific mitigation measures reduce exposures and effective communication to the public.
- Is primary prevention of asthma possible?
- Address allergic potential of biological components (mold proteins, dust mites, FEL-3, etc.).
- Practical, affordable mitigation measures.

Question 3: With the knowledge from the workshop, what additional actions can the Regions take to enhance the effectiveness of their community asthma work?

SESSION 2 (Effects and Exposure)
June 16 (morning)

? Increase asthma surveillance in local areas. (Need information at the State and municipality levels.)
? Need to educate the population about asthma (particularly schools and local physicians) and rethink outreach with new knowledge.
? Thermometer chart showing what each of us can do to limit pollutants in home.
? Use portable spirometer to identify key problem areas in homes, schools, etc.
? Indoor Environments Division should collaborate with OAQPS on asthma and provide a common message on links between ambient air pollution and indoor air pollution.
? OAQPS headquarters staff dealing with indoor air should communicate with staff concerned with outdoor/ambient air pollution in Regions.

SESSIONS 3 & 4 (Risk Evaluation and Risk Management)
June 17 (morning)

- In general, this workshop has been a great opportunity to gain a great amount of knowledge, but it is still difficult to identify specific examples of how/when to apply this knowledge. Great contacts have been made throughout the course of the workshop and perhaps once everyone gets back to the Regions, greater possibilities of application may be more readily identifiable.
- ORD can take the data being generated, and work with Regional offices in order to identify possible opportunities to do pilot studies (applied research).
- The lines of communication have been opened between ORD and Regional offices.
- Work to obtain the Regional management's support of community asthma programs.
- Begin an Intra-Regional asthma work group including other Federal agencies (e.g., HHS, educational agencies/programs and various parts of Region 7).
- Work through the CBEP in Regions.
- Create a comprehensive EPA piece incorporating outdoor air, indoor air, occupational hazards and asthma components. Put together a fact sheet on air, a slide show, and a poster listing these components and their contribution to the prevalence of asthma.
- Develop a module on asthma, which could be similar to that which exists for risk assessment.
- Repeat this workshop in two years.

- Implement the knowledge gained and more successfully do the Regional job, now with more information and better understanding.
- Put more into the review and comment on ORD Research Agenda.
- Instill a two way briefing of air directors/managers through the staff, as well as through the ORD at Air Directors Meetings.
- More coordination among the ambient and indoor air programs across the Agency (i.e., Regions, Headquarters, and ORD).

Workshop Evaluation by Regions and Programs

June 17 (late morning)

What worked?

- Meeting/networking.

? Good focus on important topic, good mix of great information.
? Switching groups increased interaction.
? Right folks participated (HQ, Programs, Regions and ORD), although include more people from OAQPS in the future.
? Shared "flavor" of what each other is doing.
? Concrete product leading to follow up (web site).
? Internal EPA-only; no worries about outside influence.
? Questions used to prepare agenda format.

Suggestions:

? Copy of video to program offices and each region.
? Encourage continued information/tech transfer.
? Biannual workshop/rotating sites.
? Solicit comments by email from on workshop evaluation. **[Not sure what this means]**
? ORD involvement in Indoor Environments (IED) strategy meetings and include other non-IED folks in special asthma sessions.
? More continuity of participants (some speakers on first day left before risk management).
? Assistance for regions to attend.
? More primer knowledge beforehand/and preread.
? More discussion time.
? Discussion questions more tailored to apply to programs.
? Better to have overheads available during presentation for notetaking.
? More presentations and posters from ROs and Program Offices; make proceedings and abstracts available for posters (informs ORD of how their data were used).
? More on effects of indoor exposures and on outdoor mitigation.

ORD Follow-Up Commitments

June 17 (late morning)

- Communication:
  - Serve as resource/contact to Regional scientists working on asthma issues.
  - Support the asthma web site by posting relevant research findings and products.
  - Periodic visits to Regional offices to talk about ORD work ongoing in the Region.
- Leverage ORD projects in the Regions, i.e., work with Regional staff to maximize the potential for successful ORD research in communities.